



HAL
open science

Transpulmonary pressures in obese and non-obese COVID-19 ARDS

Mehdi Mezidi, Florence Daviet, Paul Chabert, Sami Hraiech, Laurent Bitker,
Jean-Marie Forel, Hodane Yonis, Ines Gragueb, Francois Dhelft, Laurent
Papazian, et al.

► **To cite this version:**

Mehdi Mezidi, Florence Daviet, Paul Chabert, Sami Hraiech, Laurent Bitker, et al.. Transpulmonary pressures in obese and non-obese COVID-19 ARDS. *Annals of Intensive Care*, 2020, 10 (1), pp.129. 10.1186/s13613-020-00745-w . hal-03708119

HAL Id: hal-03708119

<https://hal.science/hal-03708119>

Submitted on 19 Mar 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

LETTER TO THE EDITOR

Open Access



Transpulmonary pressures in obese and non-obese COVID-19 ARDS

Mehdi Mezidi^{1,2}, Florence Daviet^{3,4}, Paul Chabert¹, Sami Hraiech^{3,4}, Laurent Bitker^{1,2,5}, Jean-Marie Forel^{3,4}, Hodane Yonis¹, Ines Gragueb³, Francois Dhelft¹, Laurent Papazian^{3,4}, Jean-Christophe Richard^{1,2,5} and Christophe Guerville^{3,4*} 

Abstract

Background: Data on respiratory mechanics of COVID-19 ARDS patients are scarce. Respiratory mechanics and response to positive expiratory pressure (PEEP) may be different in obese and non-obese patients.

Methods: We investigated esophageal pressure allowing determination of transpulmonary pressures (P_L) and elastances (EL) during a decremental PEEP trial from 20 to 6 cm H₂O in a cohort of COVID-19 ARDS patients.

Results: Fifteen patients were investigated, 8 obese and 7 non-obese patients. PEEP \geq 16 cm H₂O for obese patients and PEEP \geq 10 cm H₂O for non-obese patients were necessary to obtain positive expiratory P_L . Change of PEEP did not alter significantly ΔP_L or elastances in obese patients. However, in non-obese patients lung EL and ΔP_L increased significantly with PEEP increase. Chest wall EL was not affected by PEEP variations in both groups.

Background

Obesity, which is usually associated with better outcome for acute respiratory distress syndrome (ARDS) patients, is considered as a risk factor of acquiring a severe form of SARS-CoV-2-associated ARDS for SARS-CoV-2 [1]. Impact of obesity on respiratory mechanics of SARS-CoV-2-associated ARDS has not been investigated.

We hypothesized that respiratory mechanics including esophageal pressure (P_{es}) measurements might be different in obese and non-obese patients.

Therefore, the first objective of this study was to investigate transpulmonary pressures (P_L) in intubated SARS-CoV-2 patients according to their body mass index (BMI) during a decremental PEEP trial. Secondary objective was to assess lung and chest wall elastances (EL_L and EL_{CW} , respectively).

Methods

Patients

We conducted a prospective observational study in two intensive care units both in tertiary university hospitals (Hôpital de la Croix-Rousse, Hospices Civils de Lyon and Hôpital Nord, Assistance Publique-Hôpitaux de Marseille).

Patients were included in the study from 15 March to 15 April 2020 if they fulfilled inclusion criteria: adult admitted into the ICU for SARS-CoV-2, intubated and mechanically ventilated with moderate-to-severe ARDS criteria, sedated and paralyzed for clinical purpose and monitored by P_{es} catheter. As part of routine clinical management, we performed a decremental PEEP trial from 20 to 6 cm H₂O by 2 cm H₂O-steps in each patient during volume-controlled ventilation while other parameters were kept constant.

Esophageal pressure monitoring, transpulmonary pressures and elastances calculations

P_{es} catheter (Nutrivent TM, Sidam, Mirandola, Italy, or C7680U (Marquat, Boissy-St-Leger, France) was in place. The correct placement of esophageal catheter was

*Correspondence: christophe.guerville@ap-hm.fr

³ Assistance Publique - Hôpitaux de Marseille, Hôpital Nord, Médecine Intensive Réanimation, Chemin Des Bourrelly, 13015 Marseille, France
Full list of author information is available at the end of the article

confirmed by presence of cardiac artifacts on the esophageal curve and by an occlusion test (expiratory hold on the ventilator) in passive conditions with gentle chest compression. The occlusion test was considered as positive when the correlation between ΔP_{es} and Δ airway pressure (P_{aw}) was 0.8–1.2. To avoid overestimation or underestimation of esophageal pressures, we inflated the esophageal balloon with the minimal filling volume among the recommended range for each catheter which was within the flat portion of the volume–pressure curve of the balloon [2, 3].

At each PEEP step, 2-s end-inspiratory occlusion pause allowed measurement of respiratory system (RS) and esophageal plateau pressure (P_{plat} and $P_{es, insp}$ respectively), whereas 5-s end-expiratory occlusion pause allowed, respectively, measurement of RS and esophageal total PEEP ($PEEP_{tot}$ and $P_{es, exp}$ respectively). RS driving pressure (ΔP_{RS}) was calculated as P_{plat} minus $PEEP_{tot}$. RS, chest wall and lung elastances (EL_{RS} , EL_{CW} , and EL_L , respectively) and elastance ratio were computed according standard formula.

P_L absolute values were calculated as airway pressures minus esophageal pressures during inspiration ($P_{L, insp} = P_{plat} - P_{es, insp}$) and expiration ($P_{L, exp} = PEEP_{tot} - P_{es, exp}$), transpulmonary driving pressure ($\Delta P_L = P_{L, insp} - P_{L, exp}$). Elastance ratio derived P_L ($P_{L, ER}$) was calculated as $P_{plat} \times (EL_L / EL_{RS})$.

Statistics

Obesity was defined by a BMI ≥ 30 . Results are reported as medians [interquartile range] or count (percentage) and compared between groups by Mann–Whitney U. Friedman test was used for repeated variables. p value < 0.05 was considered as significant.

Results

Fifteen patients were included in the study, 8 in the obese group (median BMI 34 [33–41]) and 7 in the non-obese group (mean BMI 26 [25–29]). Patient's characteristics were comparable between groups except for age (66 [53–73] years for non-obese group vs. 44 [39–49] years for obese group, $p = 0.04$). Table 1 compares respiratory mechanics for each BMI group according to the PEEP levels. Figure 1a represents P_{plat} and ΔP_{RS} for each BMI group according to the PEEP levels. Figure 1b represents transpulmonary pressures and ΔP_L .

PEEP ≥ 16 cm H₂O for obese patients and PEEP ≥ 10 cm H₂O for non-obese patients were necessary to obtain positive $P_{L, exp}$ (Fig. 1b). At 16 cm H₂O of PEEP, 71% of non-obese patients had $P_{L, insp} \geq 20$ cm H₂O and 0% of obese patients, whereas with $P_{L, ER}$ was ≥ 20 cm H₂O in, respectively, 86% of non-obese patients and 75% of obese patients. Change of PEEP did not alter

significantly ΔP_L or elastances in obese patients (Table 1). However, in non-obese patients EL_{RS} and EL_L increased significantly with PEEP increase. EL_{CW} was not affected by PEEP variations in both groups.

Differences between obese and non-obese groups were significant at 18–20 cm H₂O of PEEP with higher P_{plat} , ΔP_{RS} , $P_{L, insp}$, ΔP_L in non-obese patients.

Discussion

During decremental PEEP trial, we found differences in transpulmonary pressures and respiratory mechanics in COVID-19 ARDS patients according to the presence of obesity. First, $P_{L, insp}$, ΔP_L were higher in non-obese patients at high PEEP (≥ 18 cm H₂O), as P_{plat} and ΔP_{RS} . Second, EL_{CW} and EL_L were not statistically different between groups. However, increase of PEEP was significantly associated with an increase of EL_L in non-obese patients. Third, high PEEP levels (i.e., 16 cm H₂O) were associated with potential injurious $P_{L, ER}$ (≥ 20 cm H₂O).

Preliminary studies with CT-scan have reported diffuse and bilateral pulmonary lesions during COVID-19 ARDS, which is usually associated with recruitability by PEEP in ARDS [4].

Recent studies using the same method to assess recruitability (recruitment-to-inflation ratio) reported conflicting data in those patients [5–7] with range from 17 to 56% of highly recruitable patients and possible less recruitable patients at a more advanced time point of the disease [5].

However, the lower driving pressures (ΔP_{RS} and ΔP_L) observed for obese patients cannot discriminate lung recruitment from less lung overdistension without appropriate evaluation (CT-scan or electrical impedance tomography for instance).

We did not check for airway flow limitation in all patients that could have led to overestimate lung and respiratory system elastances, in particular in obese patients.

Finally, we were not able to compare respiratory mechanics of this cohort with non COVID-19 ARDS patients.

In conclusion, assessment of respiratory mechanics of COVID-19 ARDS patients with transpulmonary pressure monitoring might be useful when targets of protective lung ventilation could not be reached. The characteristics of obesity on respiratory mechanics airway opening pressure, recruitability of COVID-19 ARDS patients need further investigations.

Abbreviations

ARDS: Acute respiratory distress syndrome; BMI: Body mass index; ΔP_L : Transpulmonary driving pressure; ΔP_{RS} : Respiratory system driving pressure; EL_{CW} : Chest wall elastance; EL_L : Lung elastance; EL_{RS} : Respiratory system

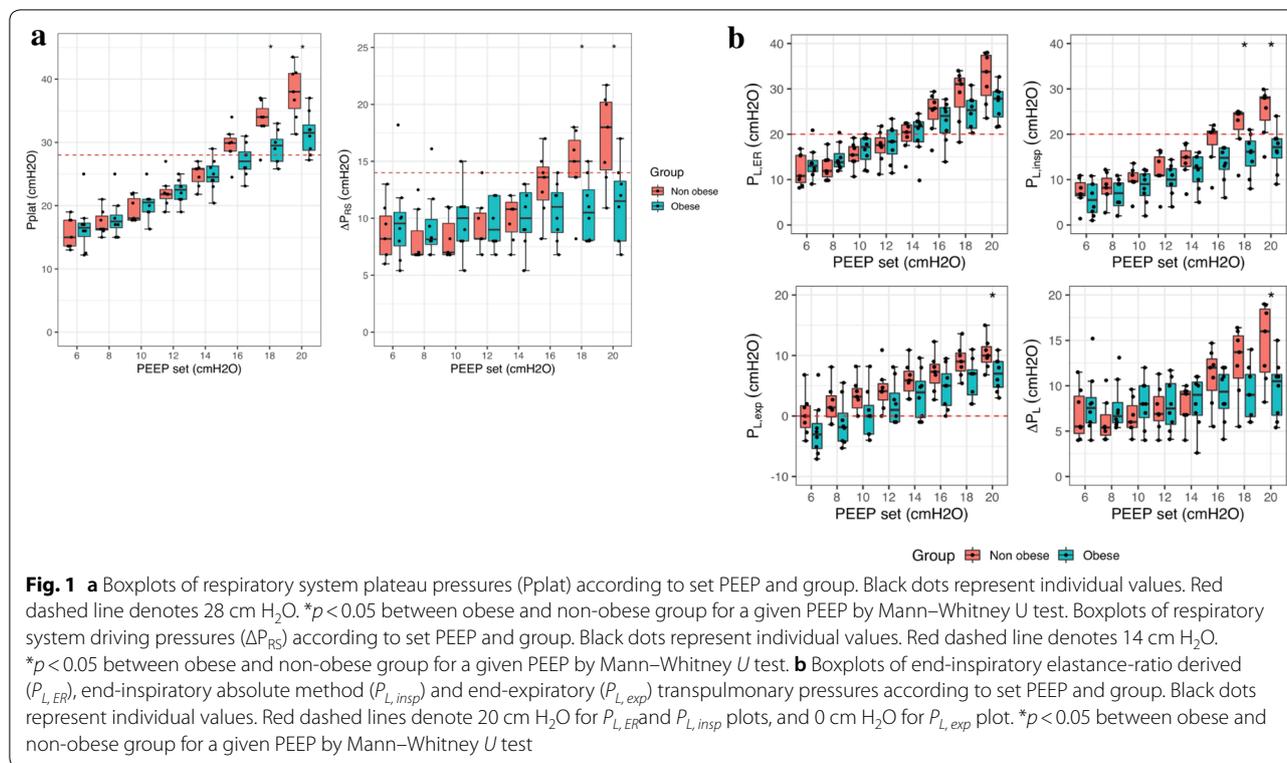
Table 1 Respiratory mechanics according to BMI group and PEEP level

Variable	BMI group	PEEP (cm H ₂ O)							
		6	8	10	12	14	16	18	20
<i>P</i> _{plat} (cm H ₂ O)	Non-obese [§]	15 [13.6–17.7]	16.3 [16.2–18.4]	18 [17.7–21.1]	21.8 [21.1–22.6]	25.8 [23.8–25.9]	29.9 [28.6–30.7]	34 [32.6–35.4]	38 [35.4–40.9]
	Obese [§]	16.5 [15.1–17.3]	17.5 [16.5–18.5]	20.5 [19–21]	22.5 [21–23.3]	24.5 [23.8–26.3]	27 [25.8–28.5]	29.5 [27–30.5]*	31.5 [28.8–32.8]*
Total PEEP (cm H ₂ O)	Non-obese [§]	6.8 [6.8–6.9]	9 [8.4–9.5]	10.9 [10.9–11]	12.2 [12.2–13.3]	15 [15–15]	16.3 [16.3–16.7]	19 [19–19]	20.4 [20.4–21.4]
	Obese [§]	6.9 [6.7–6.9]	8.7 [8.3–8.9]	10.5 [10–11]	13 [12.2–13]	15 [14–15]	16.7 [16–17]	18.5 [18–19]	20 [20–20.6]
ΔP_{RS} (cm H ₂ O)	Non-obese [§]	8.2 [6.8–10.2]	6.8 [6.8–8.9]	7 [6.8–9.6]	8.2 [8.2–10.5]	10.8 [8.8–11.4]	13.6 [11.6–14.5]	15 [13.6–16.9]	18 [14.3–20.2]
	Obese	9.6 [7.6–10.5]	8.15 [7.7–9.9]	10 [8–11]	9 [8–12]	10 [8.8–12.3]	11 [8.8–12.3]	10.5 [8.1–12.5]*	11.5 [8–13.3]*
<i>P</i> _{es,insp} (cm H ₂ O)	Non-obese [§]	8.6 [6.9–10.2]	9.4 [7.6–10.9]	10 [7.6–11.6]	10.9 [8.8–11.6]	10.9 [8.8–12.8]	10.9 [9.3–12.8]	12 [9.5–12.9]	13 [10.9–14.3]
	Obese [§]	11.5 [9.1–14.5]	11.5 [9.5–15.3]	11.5 [9.5–16.3]	12 [9.5–16]	12.5 [10.5–16.3]	12.5 [10.6–16.5]	13 [11.4–17.3]	13.5 [12.8–17.5]
<i>P</i> _{es,exp} (cm H ₂ O)	Non-obese [§]	7.1 [5.2–8.9]	7.5 [5.9–8.9]	7.8 [6.4–10.2]	8.3 [7.1–10.2]	9.1 [7.1–10.9]	9.5 [7.6–11]	10 [8.1–11.6]	11 [8.8–12.2]
	Obese [§]	9.9 [8.1–12.3]	10.5 [8.2–13]	10.5 [8.5–13.3]	11 [8.7–14]	11 [8.7–15]	11.5 [9.3–14.5]	11.5 [10.3–15.3]	12.5 [11–16]
<i>P</i> _{L,insp} (cm H ₂ O)	Non-obese [§]	6.8 [6.4–9.3]	8.2 [6.8–10.3]	9.6 [9.5–11.5]	10.9 [10.9–15]	14.9 [12.9–16.4]	20.4 [17.7–20.7]	24.5 [21.1–24.8]	28 [23.1–28.3]
	Obese [§]	5.5 [2.8–9]	7 [4.3–9.3]	9 [6.5–11.3]	10 [8.5–12.4]	12.6 [9.5–15]	14.8 [12.3–17]	16.2 [13–18.5]*	17.15 [14.8–19]*
<i>P</i> _{L,ER} (cm H ₂ O)	Non-obese [§]	10.8 [9.4–15.4]	11.9 [10.6–14.3]	15.4 [14.1–17.3]	17.6 [15.9–19.2]	20.5 [18.5–22.1]	25.7 [23.3–27.7]	31.1 [26–32.4]	33.8 [28.6–37.4]
	Obese [§]	13 [11.8–14.2]	13.8 [12.8–15.7]	17.2 [14.5–19.1]	18.4 [15.7–20.9]	21.7 [18.3–22.8]	24 [20.3–25.9]	25.3 [21.3–27.4]	27.8 [23.8–29.4]
<i>P</i> _{L,exp} (cm H ₂ O)	Non-obese [§]	0 [– 1.9 to 1.7]	1.4 [– 0.2 to 3.4]	3.2 [1.4–4.6]	4.1 [2.7–5.4]	5.9 [4.2–7.4]	7.3 [5.5–8.6]	9 [7.5–10.4]	10 [8.9–11.5]
	Obese [§]	– 3.1 [– 5.4 to – 1.3]	– 1.9 [– 4.2 to 0.5]	0 [– 3 to 1.8]	1 [– 1 to 3.8]	3.9 [– 0.3 to 5.8]	5 [1.8–7]	7 [3.5–7.6]	7 [4.8–9]*
ΔP_L	Non-obese [§]	5.5 [4.8–8.9]	5.4 [4.6–6.8]	6 [5.4–7.8]	6.9 [6.2–8.8]	9.1 [6.8–9.4]	12 [9.5–13]	13.7 [10.9–15.5]	16 [11.5–18.5]
	Obese	7.6 [5.9–8.7]	6.7 [5.9–8.2]	8 [6.5–10]	7.5 [5.8–10.3]	9 [6.8–10.4]	9.4 [7.5–11.3]	9 [6.6–11.3]	10.5 [6.8–11.3]*
<i>EL</i> _{RS} (cm H ₂ O. L ⁻¹)	Non-obese [§]	20 [17.4–23.8]	18.3 [15.6–23.2]	18.3 [17–23.3]	24.1 [18.4–26.4]	24 [22.7–28.9]	33.3 [27.4–38.3]	39.3 [32–43]	47.1 [33.5–54.1]
	Obese	27.3 [18.5–38.1]	26.3 [18–38.3]	25.1 [17.6–53.7]	26.7 [18–49.1]	30.1 [18.6–48.5]	31.4 [19.9–53.4]	29.2 [23.3–45.9]	31.4 [22.9–45.9]
<i>EL</i> _{CW} (cm H ₂ O. L ⁻¹)	Non-obese	4.6 [3.8–5.7]	5.8 [4.7–6.2]	3.2 [3.1–5.2]	5.2 [3.5–6.3]	5.2 [3.6–6.3]	5.2 [3.6–6.3]	3.8 [3.2–6.2]	6.2 [4.7–6.3]
	Obese	4.2 [4–5.7]	4.2 [3.5–7.1]	4.8 [2.7–7.8]	4.9 [2.7–8.2]	4.8 [4.2–8.4]	5.7 [2.7–8.2]	4.2 [3.5–6.7]	3.9 [2.7–6.7]
<i>EL</i> _L (cm H ₂ O. L ⁻¹)	Non-obese [§]	15.9 [11.6–20.7]	13.1 [10.9–17.8]	15.7 [13.7–19.6]	20.3 [13.8–22.2]	20.9 [17.7–24.6]	30.2 [22.5–33.8]	36.4 [25.7–39.8]	41.9 [27.2–48.7]
	Obese	23.3 [14.6–32.4]	22.3 [15.3–30.7]	22.6 [14.9–42]	23.2 [12.8–39.8]	26.4 [14.2–42.5]	28.9 [16.1–43.6]	25.2 [19.9–36.6]	28.9 [20.3–38.8]
EL ratio	Non-obese [§]	0.79 [0.67–0.87]	0.75 [0.66–0.80]	0.8 [0.79–0.84]	0.81 [0.74–0.84]	0.83 [0.74–0.85]	0.86 [0.8–0.9]	0.9 [0.79–0.92]	0.89 [0.81–0.9]
	Obese [§]	0.8 [0.77–0.85]	0.80 [0.78–0.85]	0.84 [0.74–0.89]	0.82 [0.72–0.89]	0.85 [0.77–0.86]	0.87 [0.79–0.9]	0.85 [0.8–0.9]	0.88 [0.79–0.91]

Variables are reported as medians [interquartile range]

BMI body mass index, *PEEP* positive end-expiratory pressure, *P*_{plat} plateau pressure, ΔP_{RS} respiratory system driving pressure, *P*_{es,insp} esophageal inspiratory pressure, *P*_{es,exp} esophageal expiratory pressure, *P*_{L,insp} inspiratory transpulmonary pressure, *P*_{L,ER} transpulmonary pressure calculated with the elastance ratio, *EL* ratio, *P*_{L,exp} expiratory transpulmonary pressure, ΔP_L driving transpulmonary pressure, *EL*_{RS} respiratory system elastance, *EL*_{CW} chest wall elastance, *EL*_L lung elastance, *EL* ratio, ratio of lung elastance to elastance of the respiratory system.

**p* < 0.05 between obese and non-obese group for a given PEEP by Mann–Whitney *U* test; [§]*p* < 0.05 for PEEP effect by Friedman test. Computed for each group



elastance; ICU: Intensive care unit; PEEP: Positive end-expiratory pressure; P_{es} : Esophageal pressure; $P_{L,ER}$: Inspiratory transpulmonary pressure (elastance ratio); $P_{L,exp}$: Expiratory transpulmonary pressure; $P_{L,insp}$: Inspiratory transpulmonary pressure (absolute value); P_i : Transpulmonary pressure; P_{plat} : Plateau pressure; SARS-CoV-2: Severe acute respiratory syndrome coronavirus.

Acknowledgements

The authors want to acknowledge Sabine Valera for the English editing and all the nurses, caregivers, physiotherapists, doctors and support peoples involved in the COVID-19 crisis in both centers.

Authors' contributions

MM and CG were responsible for the concept, revision and approval of this manuscript. MM, SH and CG participated in the design and drafted the manuscript. LP and JCR helped to revise the manuscript. MM, FD, PC, SH, LB, JMF, HY, IG, FD, LP, JCR and CG contributed to the data analysis and interpretation. All authors read and approved the final manuscript.

Funding

No specific funding was used for this study.

Availability of data and materials

The datasets analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

All patients admitted for SARS-CoV-2 or their relatives in case of unable to be informed patients, received non-opposition information to be part of the French clinical data base (COVID-ICU). The study was approved by an Ethic Committee, through the French national registry COVID-ICU for patients included in Marseille and through the Lyon University for patients included in Lyon (#20–41).

Consent for publication

All authors reviewed the manuscript and approved the publication of the manuscript. The corresponding author has completed the “Consent for publication”.

Competing interests

The authors have no competing interests to declare.

Author details

¹ Medical ICU, Croix-Rousse Hospital, Hospices Civils de Lyon, Lyon, France. ² Lyon 1 University, Lyon, France. ³ Assistance Publique - Hôpitaux de Marseille, Hôpital Nord, Médecine Intensive Réanimation, Chemin Des Bourrelly, 13015 Marseille, France. ⁴ Aix-Marseille Université, Faculté de médecine, Centre d'Etudes et de Recherches sur les Services de Santé et qualité de vie EA 3279, 13005 Marseille, France. ⁵ CREATIS, CNRS UMR5220, INSERM U1044, INSA, Lyon, France.

Received: 22 April 2020 Accepted: 23 September 2020

Published online: 01 October 2020

References

1. Simonnet A, Chetboun M, Poissy J, et al. High prevalence of obesity in severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) requiring invasive mechanical ventilation. *Obesity*. 2020. <https://doi.org/10.1002/oby.22831>.
2. Akoumianaki E, Maggiore SM, Valenza F, et al. The application of esophageal pressure measurement in patients with respiratory failure. *Am J Respir Crit Care Med*. 2014 Mar 1;189(5):520–31. <https://doi.org/10.1164/rccm.201312-2193CI.Review> PubMed PMID: 24467647.

3. Mojoli F, Iotti GA, Torriglia F, et al. In vivo calibration of esophageal pressure in the mechanically ventilated patient makes measurements reliable. *Crit Care*. 2016;20:98. <https://doi.org/10.1186/s13054-016-1278-5>.
4. Chiumello D, Marino A, Brioni M, et al. Visual anatomical lung CT scan assessment of lung recruitability. *Intensive Care Med*. 2013;39(1):66–73. <https://doi.org/10.1007/s00134-012-2707-9>.
5. Pan C, Chen L, Lu C, et al. Recruitability in SARS-CoV-2 associated acute respiratory distress syndrome: a single-center, observational study. *Am J Respir Crit Care Med*. 2020. <https://doi.org/10.1164/rccm.202003-0527LE> [Epub ahead of print] **PubMed PMID: 32200645**.
6. Beloncle FM, Pavlovsky B, Desprez C, et al. Recruitability and effect of PEEP in SARS-Cov-2-associated acute respiratory distress syndrome. *Ann Intensive Care*. 2020;10(1):55. <https://doi.org/10.1186/s13613-020-00675-7>.
7. Haudebourg AF, Perier F, Tuffet S, et al. Respiratory Mechanics of COVID-19 vs. Non-COVID-19 associated acute respiratory distress syndrome. *Am J Respir Crit Care Med*. 2020. <https://doi.org/10.1164/rccm.202004-1226LE>.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Submit your manuscript to a SpringerOpen[®] journal and benefit from:

- ▶ Convenient online submission
- ▶ Rigorous peer review
- ▶ Open access: articles freely available online
- ▶ High visibility within the field
- ▶ Retaining the copyright to your article

Submit your next manuscript at ▶ [springeropen.com](https://www.springeropen.com)
